UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5

DATE: November 9, 2005

SUBJECT: Draft Final Screening Ecological Risk Assessment, USX Vessel Slips Site, Chicago, Illinois

FROM: David Brauner, Ecologist

TO: Sharon Jaffess, RPM

I have performed a basic Screening Ecological Risk Assessment for the USX site.

1.0 Site Description:

The USX Vessel Slips Site is a highly industrialized area at the mouth of the Calumet River in southeast Chicago, Illinois. The Calumet River at this point is channelized with no riparian ecological resources.

2.0 Problem Formulation:

2.1 Data sources:

This assessment includes sample data from the following locations/sources:

- Calumet River
- Lake Michigan
- USX North Vessel Slip
- USX South Vessel Slip
- Material dredged by the U.S. Army Corps of Engineers in 1984, 1994, 2001

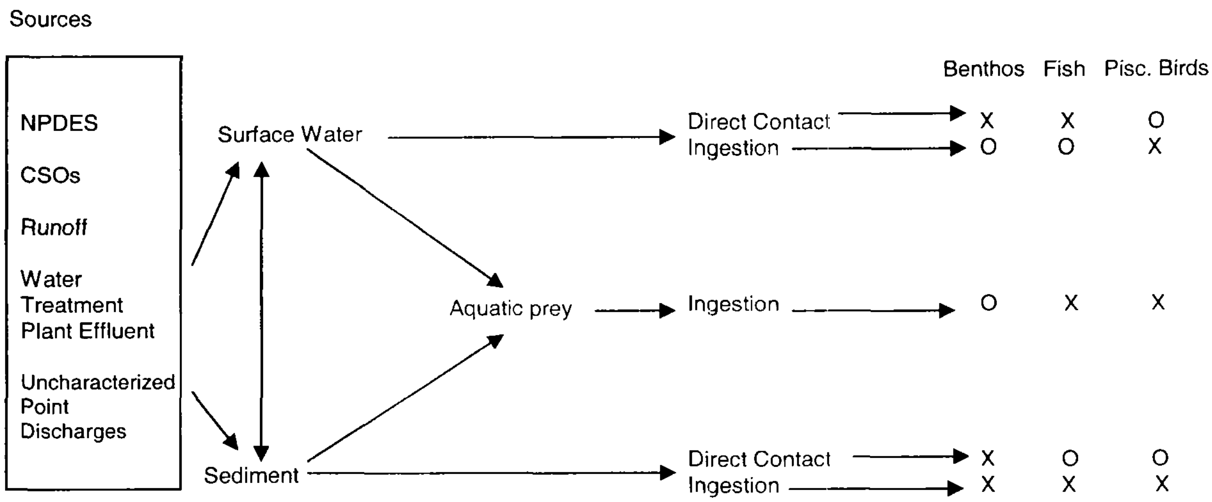
According to several literature sources, the bioactive zone in sediments may extend as deep as 1 meter and possibly even deeper. The typical range of depths reported is approximately 20 to 50 cm below the surface of the sediment. Table 1 presents screening results using samples only 2 feet or shallower: samples at 3 feet or deeper and the deep auger samples are excluded. Although there are no depths as such, the dredged materials composite samples are included in Table 1. For comparison purposes, Table 2 presents screening results for the deeper samples.

2.2 Ecological Resources and Potential Receptors:

The potential ecological receptors at the USX Vessel Slips site are likely limited to more tolerant species of benthic invertebrates, including Asiatic clams (*Corbicula fluminea*), zebra mussels (*Dreissna polymorpha*), midge larvae (fam. Chironomidae), aquatic worms (fam. Oligochaeta), fish species such as white perch (*Morone americanus*), alewife (*Alosa pseudoharengus*), gizzard shad (*Dorosma cepedianum*), sculpin (fam. Cottidae), yellow perch (*Perca flavescens*), sunfish (fam. Centarchidae), goldfish-carp hybrids; channel catfish (*Ictalurus punctatus*), and common carp (*Cyprinus carpio*); and, potentially, opportunistic piscivorous birds.

2.3 Conceptual Site Model and Potentially Complete Ecological Exposure Pathways:

Figure 1. Conceptual Site Model for USX Vessel Slips Site, Chicago, IL



Key: X – potentially complete exposure pathway; O – exposure pathway incomplete; arrows indicate contaminant movement through the local ecosystem.

Exposure to contaminants through direct contact with contaminated media is likely limited in birds due to dermal barriers such as feathers. Toxicity due to this form of exposure is also not well described in the literature. Ingestion of sediment and surface water is likely to be incidental for piscivorous birds and a less significant pathway than ingestion of contaminated prey items. Depending on the species, exposure via ingestion of, and contact with, contaminated media may be considered to be incidental for fish as well. These pathways may be relatively more important for species such as the channel catfish that tend to be in contact with sediments for extended periods of time.

Because the area is highly industrialized and there is no riparian (river bank) habitat to support ecological receptors, piscivorous birds may be opportunistic and occasional visitors and predators, and not regular users of the site.

2.4 Assessment Endpoints and Measures of Effect:

Assessment Endpoints	Measures of Effect
Maintenance of benthic invertebrate community	• Comparison of sediment and surface water concentrations to established screening benchmarks and toxicity reference values (TRVs); • Benthic community metrics
Reproduction and survival of fish	• Comparison of sediment and surface water concentrations to established screening benchmarks and TRVs;

	• Comparison of tissue residue levels to established TRVs
Reproduction and survival of piscivorous birds	• Comparison of sediment and surface water concentrations to established screening benchmarks and TRVs; • Comparison of modeled contaminant concentrations to established TRVs

2.5 Screening Benchmarks:

The Consensus-based Sediment Quality Guidelines (MacDonald et al., 2000a) were used for screening purposes, except for those Contaminants of Potential Ecological Concern (COPECs) for which SQGs were not available:

- Barium (Buchman 1999)
- Cyanide, iron, manganese (Pesaud et al. 1993)
- PCBs (MacDonald et al. 2000b)

2.6 Contaminant Fate and Transport

See Appendix A for a brief discussion of the COPECs detected at the USX site and dredged material.

2.7 Bioaccumulation

The following COPECs detected at the USX Vessel Slips site have the potential for bioaccumulation (USEPA 2000): arsenic, cadmium, chromium (VI), copper, lead, methylmercury, nickel, and zinc.

3.0 Results:

3.1 Shallow Samples:

This section only describes metals detected in the Calumet River, Lake Michigan, and the USX Vessel Slips, and NOT the dredged materials.

Maximum concentrations for every detected COPEC exceeded screening benchmarks in all three locations with the following exceptions:

1. Arsenic in Lake Michigan
2. Copper in Lake Michigan

All of the detected metals were detected in the USX Slips; and most were detected in Lake Michigan and the Calumet River. However, the following COPECs were not detected in these locations:

1. Arsenic (Calumet River)
2. Chromium (Calumet River)
3. Nickel (Calumet River)
4. Mercury (Calumet River, Lake Michigan, USX Slips)

For all detected COPECs, the maximum concentrations were greater in the USX Slips than both the Calumet River and Lake Michigan.

3.2 Deep Samples:
This section only describes metals detected in the Calumet River, Lake Michigan, and the USX Vessel Slips, and NOT the dredged materials.

Maximum concentrations of the following detected COPECs exceeded screening benchmarks:

- Arsenic (Calumet River)
- Cadmium (Calumet River, USX Slips)
- Chromium (Lake Michigan, USX Slips)
- Copper (Calumet River, USX Slips)
- Lead (USX Slips)
- Mercury (USX Slips)
- Zinc (Calumet River, USX Slips)

Nickel was not detected in any deep sample. COPECs not described in the list above were not detected (e.g., arsenic was not detected in Lake Michigan or USX slips deep samples).

3.3 Comparison of Shallow and Deep Samples:

Except for lead in Lake Michigan, for COPECs detected in both shallow and deep samples, maximum concentrations were higher in the deep samples at each location. The maximum lead concentration in Lake Michigan was greater in the shallow samples. All COPECs were detected in shallow samples in at least one location (Cal. River, L. Michigan, and/or the USX slips), except for mercury. Mercury was only detected in one deep sample (USX slips). Nickel was not detected in any deep samples. Otherwise, all COPECs were detected in at least one sample in at least location.

3.4 Dredged Material Samples:

With the exception of barium and ammonia (no screening benchmark available for ammonia), COPEC concentrations in all composite samples for all three years exceeded their respective screening benchmarks.

There were no ammonia screening benchmarks available; thus, because ammonia was detected in all three dredged composite samples, this represents a source of uncertainty.

4.0 Uncertainty:

There are several sources of uncertainty in this Screening Ecological Risk Assessment analysis.

1) There are no screening benchmarks available for ammonia.

2) The number of samples in the Calumet River and Lake Michigan are limited and may not fully characterize the nature and extent of the contamination in the area.

3) Data for PAHs and PCBs were not included in the data available for analysis.

4) The actual ecological receptors are not known.

5) The fate and transport and actual sources of the contamination in the USX Slips is not fully understood.

6) Surface water samples were either not taken or not available.

7) The screening benchmark for barium is for marine sediments.

8) The data do not indicate if the chromium detected was Cr (III) or Cr (VI) or some combination of the two.

5.0 Conclusions:

All of the detected metals show the potential for ecological risk in the USX Vessel Slips Site. There is a potential for ecological risk in the Calumet River from cadmium, copper, lead, and zinc. There is a potential for ecological risk in Lake Michigan from all COPECs except arsenic and mercury. However, there are insufficient samples in the Calumet River and Lake Michigan to fully characterize the nature and extent of contamination in the area of the USX Slips site.

All of the samples of dredged materials showed the potential for ecological risk from all COPECs described above, except for barium.

Additional sediment samples should be taken in the Calumet River and Lake Michigan; surface water samples should be taken from all three locations; benthic invertebrate toxicity tests are recommended; development of biota-sediment-accumulation factors (BSAFs) and food web modeling are recommended; characterization of the ecological receptors present at the site should be done.

All detected COPECs, including mercury, should be evaluated further in the next stage of evaluation and characterization of ecological risk at this site.

I may be contacted at 6-1526 if you have questions or comments. Please fill out the attached evaluation form and return it to Tom Short, SR-6J. The information is used to assess and improve our services.

cc: Tom Short, Section Chief, RRS #1

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Table 1. Screening Results for shallow samples in Calumet River, Lake Michigan, USX Vessel Slips, and USACE dredged materials.

COPEC	Location	Max. Conc. (mg/kg)	Screening Benchmark (mg/kg) (a)	HQ	Frequency of Detection	No. Exceed.	Note
Arsenic	Cal. River	ND	9.79	NC	0/3	0/3	
Arsenic	Lk. Mich.	9.2	9.79	0.94	1 / 3	0 / 3	
Arsenic	USX Slips	42.1	9.79	**4.30**	1 / 20	1 /20	
Arsenic	2001	57.9	9.79	**5.91**			(b)
Arsenic	1994	27	9.79	**2.76**			(b)
Arsenic	1984	124	9.79	**12.67**			(b)
Cadmium	Cal. River	2.3	0.99	**2.32**	3 /3	3 /3	
Cadmium	Lk. Mich.	1.5	0.99	**1.51**	3 /3	2 /3	
Cadmium	USX Slips	6.5	0.99	**6.57**	2 /20	2 /20	
Cadmium	2001	6.2	0.99	**6.26**			(b)
Cadmium	1994	4.8	0.99	**4.85**			(b)
Cadmium	1984	15.6	0.99	**15.76**			(b)
Chromium	Cal. River	ND	43.4	NC	0 /3	0 /3	
Chromium	Lk. Mich.	50.4	43.4	**1.16**	3 /3	1 /3	
Chromium	USX Slips	231	43.4	**5.32**	6 /20	3 /20	
Chromium	2001	347	43.4	**8.00**			(b)
Chromium	1994	101	43.4	**2.33**			(b)
Chromium	1984	347	43.4	**8.00**			(b)
Copper	Cal. River	67.5	31.6	**2.14**	2 /3	2 /3	
Copper	Lk. Mich.	28.6	31.6	0.91	1 /3	0 /3	
Copper	USX Slips	289	31.6	**9.15**	8 /20	8 /20	
Copper	2001	118	31.6	**3.73**			(b)
Copper	1994	131	31.6	**4.15**			(b)
Copper	1984	131	31.6	**4.15**			(b)
Lead	Cal. River	111	35.8	**3.10**	3 /3	3 /3	
Lead	Lk. Mich.	55.4	35.8	**1.55**	3 /3	3 /3	
Lead	USX Slips	507	35.8	**14.16**	11 /20	11 /20	
Lead	2001	367	35.8	**10.25**			(b)
Lead	1994	639	35.8	**17.85**			(b)
Lead	1984	639	35.8	**17.85**			(b)
Nickel	Cal. River	ND	22.7	NC	0 /3	0 /3	
Nickel	Lk. Mich.	27.2	22.7	**1.20**	1 /3	1 /3	
Nickel	USX Slips	184	22.7	**8.11**	1 /20	1 /20	
Nickel	2001	61	22.7	**2.69**			(b)
Nickel	1994	63	22.7	**2.78**			(b)
Nickel	1984	73.7	22.7	**3.25**			(b)

Mercury	Cal. River	ND	0.18	NC	0 /3	0 /3	
Mercury	Lk. Mich.	ND	0.18	NC	0 /3	0 /3	
Mercury	USX Slips	ND	0.18	NC	0 /20	0 /20	
Mercury	2001	0.62	0.18	**3.44**			(b)
Mercury	1994	0.57	0.18	**3.17**			(b)
Mercury	1984	0.9	0.18	**5.00**			(b)
Zinc	Cal. River	316	121	**2.61**	3 /3	3 /3	
Zinc	Lk. Mich.	165	121	**1.36**	1 /3	1 /3	
Zinc	USX Slips	1010	121	**8.35**	3 /20	3 /20	
Zinc	2001	1060	121	**8.76**			(b)
Zinc	1994	1920	121	**15.87**			(b)
Zinc	1984	2300	121	**19.00**			(b)
Barium	2001	86	48,000	0.0018			(b); marine sediments
Barium	1994	75	48,000	0.0016			(b); marine sediments
Barium	1984	190	48,000	0.0040			(b); marine sediments
Iron	2001	82,800	20,000	**4.14**			(b)
Iron	1994	120,000	20,000	**6.00**			(b)
Iron	1984	151,000	20,000	**7.55**			(b)
Manganese	2001	3980	460	**8.65**			(b)
Manganese	1994	2080	460	**4.52**			(b)
Manganese	1984	3980	460	**8.65**			(b)
Cyanide	2001	2.1	0.1	**21.0**			(b)
Cyanide	1994	1.4	0.1	**14.0**			(b)
Cyanide	1984	5.1	0.1	**51.0**			(b)
Ammonia	2001	255	NA	NC			(b)
Ammonia	1994	293	NA	NC			(b)
Ammonia	1984	293	NA	NC			(b)
PCBs (total)	2001	4.1	0.035	**117.14**			(b)
PCBs (total)	1994	7.3	0.035	**208.57**			(b)
PCBs (total)	1984	19	0.035	**542.86**			(b)

Notes:
(a) All screening benchmarks are from MacDonald et al. (2000a), except: barium (Buchman 1999), cyanide, iron, manganese (Persaud et al. 1993), ammonia (no benchmark available), and PCBs (MacDonald et al. 2000b).
(b) Composites of samples taken from dredged materials, removed by the Army Corps of Engineers in 1984, 1994, and 2001.
ND – Not detected;
NA – Not applicable or not available;
NC – Not calculated;

Table 2. Screening Results for deep samples in Calumet River, Lake Michigan, USX Vessel Slips, and USACE dredged materials.

COPEC	Location	Max. Conc. (mg/kg)	Screening Benchmark (mg/kg) (a)	HQ	Frequency of Detection	No. Exceed.
Arsenic	Cal. River	78.7	9.79	**8.04**	1 /1	1 /1
Arsenic	Lk. Mich.	ND	9.79	NC	0 /1	0 /1
Arsenic	USX Slips	ND	9.79	NC	0 /8	0 /8
Cadmium	Cal. River	2.1	0.99	**2.12**	1 /1	1 /1
Cadmium	Lk. Mich.	ND	0.99	NC	0 /1	0 /1
Cadmium	USX Slips	11.8	0.99	**11.91**	2 /20	2 /20
Chromium	Cal. River	ND	43.4	NC	0 /1	0 /1
Chromium	Lk. Mich.	876	43.4	**20.18**	1 /1	1 /1
Chromium	USX Slips	1030	43.4	**23.73**	5 /8	3 /8
Copper	Cal. River	92.3	31.6	**2.92**	1 /1	1 /1
Copper	Lk. Mich.	ND	31.6	NC	0 /1	0 /1
Copper	USX Slips	386	31.6	**12.22**	6 /8	6 /8
Lead	Cal. River	184	35.8	**5.14**	1 /1	1 /1
Lead	Lk. Mich.	16.7	35.8	0.47	1 /1	0 /1
Lead	USX Slips	1140	35.8	**31.84**	6 /8	6 /8
Nickel	Cal. River	ND	22.7	NC	0 /1	0 /1
Nickel	Lk. Mich.	ND	22.7	NC	0 /1	0 /1
Nickel	USX Slips	ND	22.7	NC	0 /8	0 /8
Mercury	Cal. River	ND	0.18	NC	0 /3	0 /3
Mercury	Lk. Mich.	ND	0.18	NC	0 /3	0 /3
Mercury	USX Slips	0.35	0.18	**1.94**	1 /8	1 /8
Zinc	Cal. River	413	121	**3.41**	1 /1	1 /1
Zinc	Lk. Mich.	ND	121	NC	0 /1	0 /1
Zinc	USX Slips	5240	121	**43.31**	3 /8	3 /8

Notes:
(a) All screening benchmarks are from MacDonald et al. (2000a)
ND – Not detected;
NA – Not applicable or not available;
NC – Not calculated;

Appendix A. Toxicity Profiles for Detected Contaminants

Arsenic

Arsenic has been shown in plants to cause inhibition of light activation, wilting, chlorosis, browning, dehydration, and mortality (Eisler 1988a). It can cause mortality in soil microbiota and earthworms. There have been shown to be carcinogenic and mutagenic effects in aquatic organisms, with effects including behavioral impairments, growth reduction, appetite loss, and metabolic failure. Bottom feeders are more susceptible to arsenic. Avian tolerance to arsenic varies, but effects include destruction of gut blood vessels, hepatocyte damage, muscular incoordination, debility, slowness, jerkiness, falling, hyperactivity, fluffed feathers, drooped eyelids, immobility, seizures, and systemic, growth, behavioral, and reproductive problems (Stanley et al. 1994; Whitworth et al. 1991; Camardese et al. 1990). Arsenic is a carcinogen, teratogen, and possible mutagen in mammals (ATSDR 1993). Chronic exposure can result in fatigue, gastrointestinal distress, anemia, neuropathy, and skin lesions that can develop into skin cancer in mammals.

Barium

Elevated levels of barium can induce a wide range of effects in mammals including gastrointestinal distress, muscular paralysis, and cardiovascular effects. Barium is not bioaccumulated and concentrations in higher species rarely exceed 10 mg/kg (Moore 1991).

Cadmium

Cadmium is highly toxic to wildlife and is carcinogenic and teratogenic and potentially mutagenic, with severe sublethal and lethal effects at low environmental concentrations (Eisler 1985a). It is associated with increased mortality, and effects on respiratory functions, enzyme levels, muscle contractions, growth reduction, and reproduction. It is a bioaccumlant at all levels. It accumulates in the livers and kidneys of fish (Sindayigaya, et al. 1994; Sadiq 1992). Crustaceans appear to be more sensitive to cadmium than fish and molluscs (Sadiq 1992). Cadmium can be toxic to plants at lower soil concentrations than other heavy metals and is more readily taken up than other metals (EPA 1981). On the other hand, some insects can accumulate high levels of cadmium without adverse effects (Jamil and Hussain 1992).

Chromium

There is no significant biomagnification by chromium in aquatic food webs (ATSDR, 1993). However, there are a wide range of adverse effects in aquatic organisms. In benthic invertebrates there has been observed reduced fecundity and survival, growth inhibition, and abnormal movement patterns (EPA 1976). Fish experienced reduced growth, chromosomal aberrations, reduced disease resistance, and morphological changes.

Copper

Copper is highly toxic in aquatic environments and has effects in fish, invertebrates, and amphibians (EPA 1992; Horne and Dunson 1995). Copper is highly toxic to amphibians, with adverse effects in tadpoles and embryos, and mortality and sodium loss (Horne and Dunson 1995; Owen 1981). Copper will bioconcentrate in many different organs in fish and molluscs (Owen 1981). Toxic effects in birds include reduced growth rates, lowered egg production, and developmental abnormalities (Owen 1981).

Iron

Information on the toxicity effects of iron is very limited.

Lead

Lead is carcinogenic, and adversely effects reproduction, liver and thyroid function, disease resistance (Eisler 1988b). It can be bioconcentrated from water, but does not bioaccumulate and tends to decrease with increasing trophic levels in freshwater habitats (Eisler 1988b). However, there are limited observed adverse effects in amphibians, including loss of sodium, reduced learning capability, and developmental problems (Horne and Dunson 1995). Fish exposed to high levels of lead exhibit a wide-range of effects including muscular and neurological degeneration and destruction, growth inhibition, mortality, reproductive problems, and paralysis (Eisler 1988b; EPA 1976). At elevated levels lead can cause reduced growth, photosynthesis, mitosis, and water absorption (Eisler 1988b). Birds and mammals suffer effects from lead poisoning such as damage to the nervous system, kidneys, liver, sterility, growth inhibition, developmental retardation, and detrimental effects in blood (Eisler 1988b; Amdur et al. 1991).

Manganese

Elevated levels of manganese in birds have been shown to cause the following effects: decreased hemoglobin, anemia, reduced growth; in mammals, effects include alterations of brain chemicals, gastric irritation, delayed testicular development, low birth weights, behavioral changes, and muscular weakness (ATSDR 1991).

Mercury

Mercury is a mutagen, teratogen, and carcinogen, with toxicity and environmental effects varying with its form, dose, and route of ingestion, and with the exposed organism's species, sex, age, and general condition (Eisler, 1987a, Fimreite 1979). There is a high potential for bioaccumulation and biomagnification with mercury, with biomagnified concentrations reported in fish up to 100,000 times the ambient water concentrations (Eisler 1987a, Callahan et al. 1979).

In invertebrates, effects range from non-observable to chromosomal abnormalities in some flies and reduced segment regeneration in worms (Eisler 1987a). Mercury can inhibit frog metamorphosis and many effects in fish. Those effects include loss of appetite, brain lesions, cataracts, abnormal motor coordination, and behavioral changes (MacDonald 1993). There are also effects on reproduction, growth, behavior, metabolism, blood chemistry, osmoregulation, and oxygen exchange at relatively low concentrations of mercury (Eisler 1987a). There are similar effects in birds, including delayed testicular development, altered mating behavior, reduced fertility, reduced survivability and growth in young, and gonadal atresia. In mammals, it has been shown that mercury can cause ataxia, aphagia, tremors, and diminished movement coordination (ATSDR 1994). There are varied neurological and reproductive effects as well (Cagiano et al. 1990; Khera et al. 1973).

Nickel

Observed effects of nickel (a carcinogen and mutagen) in aquatic environments include tissue damage, genotoxicity, and growth reduction (Environment Canada 1994a). Molluscs and crustaceans are more sensitive than other organisms.

Zinc

In many types of aquatic organisms, the following can be adversely affected by elevated zinc levels: growth, survival, and reproduction (Eisler 1993). Zinc in aquatic systems tends to be partitioned into sediment and less frequently dissolved as hydrated zinc ions and organic and inorganic complexes (MacDonald 1993). Zinc is toxic to plants at elevated levels, causing adverse effects on growth, survival, and reproduction (Eisler 1993). Elevated zinc levels can cause mortality, pancreatic degradation, reduced growth, and decreased weight gain in birds (Eisler 1993; NAS 1980)

POLYCHLORINATED BIPHENYLS (*PCBs*)

PCBs are mutagenic, carcinogenic, and teratogenic. They are readily absorbed through the gut, respiratory system, and skin in mammals and will concentrate in the liver, blood, muscle, adipose tissue, and skin (Eisler 1986). Mutagenic activity tends to decrease with increasing chlorination (USEPA 1980).

In general, in aquatic systems, increased toxicity is associated with increasing exposure, younger developmental stages, crustaceans, and lower chlorinated biphenyls (Eisler 1986). An increase in somatic mutations has been observed in ostrich ferns (*Matteuccia struthiopteris*).

Toxic effects in avian species included the following: morbidity, tremors, upward pointing beaks, muscular incoordination, and hemorrhagic areas in the liver (Eisler 1986). Other sublethal effects include delayed reproduction and chromosomal aberrations in Ringed Turtle-doves; courtship and nest building behavioral impairments in Mourning Doves; reduced hatchability in chicken eggs; and decline in sperm concentration in American Kestrels. However, birds tend to more resistant to acute exposure than other groups: no adverse reproductive effects were observed in Screech Owls fed 3 ppm PCB diets or in Japanese Quail, Northern Bobwhites, and Mallard Ducks.

There are a number of effects observed in aquatic organisms due to exposure to PCBs (Eisler 1986). They include growth reduction in algae and brook trout; reduced egg survival and reduced fertilization success in flounder, minnows, sea urchins (prior to fertilization, eggs were more resistant to PCBs at insemination and afterwards); and complete reproductive failure in brook trout. Carcinogenic and biochemical perturbations were observed in trout liver cells and marine teleosts; with anemia, hyperglycemia, and altered cholesterol metabolism in brown trout fed diets with 10 ppm PCBs (USEPA 1980).

Appendix A. References

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